Express Mail No. EL977101169US   PATENT
Atty. Docket No. 030216

19

WE CLAIM:

1.   A method for determination of link latency in a communication network having a link, the method comprising steps of:

        (a)   determining an unloaded network delay for round trip traversal of the link according to an initial registration process;

        (b)   setting a current estimated delay equal to the unloaded network delay;

        (c)   upon commencement of a subsequent registration attempt, initiating a current round trip estimation process having a start time and an end time;

        (d)   setting a retry timer equal to the sum of a predetermined backoff period and the current estimated network delay;

        (e)   if the retry timer expires before the end time of the potentially concurrent current round trip estimation process, updating the predetermined backoff period and repeating steps (c) and (d); and

        (f)   at the end of the subsequent registration, resetting the current estimated delay equal to the difference between the end time of the current round trip estimation process and the start time of the current round trip estimation process.

2.   The method of Claim 1, further comprising an initial step of providing a wireless communication sub-network incorporating the link.

3.   The method of Claim 2, wherein the wireless communication sub-network utilizes Mobile IP.

4.   The method of Claim 3, wherein the link further comprises a link between a mobile device and a home agent.

Express Mail No. EL977101169US   PATENT
Atty. Docket No. 030216

20

5.   The method of Claim 4, wherein the current round trip estimation process further comprises a re-registration subprocess.

6.   The method of Claim 5, wherein the start time further comprises a send time of a re-registration request.

7.   The method of Claim 5, wherein the end time further comprises a receipt time of a re-registration reply.

8.   A method for determination of link latency in a Mobile IP network, the method comprising steps of:

        (a)   determining an unloaded network delay according to an initial registration process;

        (b)   setting a current estimated delay equal to the unloaded network delay;

        (c)   upon commencement of a re-registration attempt, noting a send time of a current round trip estimation process;

        (d)   setting a retry timer equal to the sum of a predetermined backoff period and the current estimated network delay;

        (e)   and if the retry timer expires before receipt of a re-registration reply, updating the predetermined backoff period and repeating steps (d) and (e);

        (f)   and if the retry timer does not expire before receipt of the re-registration reply, noting the receipt time of the current round trip estimation process and resetting the current estimated delay equal to the difference between the receipt time and the send time.

9.   The method of Claim 8, wherein the initial registration process further comprises the steps of:

        noting a send time of an initial registration request from the mobile device to

Express Mail No. EL977101169US   PATENT
Atty. Docket No. 030216

21

the home agent;

noting a receipt time of a registration reply corresponding to the initial registration request from the home agent to the mobile device; and

determining the unloaded network delay according to the formula:

$$RTT(0) = (RRP(initial) - RRQ(initial)),$$

wherein $RTT(0)$ represents the initial registration round trip delay, $RRP(initial)$ represents the receipt time of the initial registration reply sent by the HA, and $RRQ(initial)$ represents the send time of the initial registration request.

10.   The method of Claim 8, wherein the current round trip estimation process further comprises a re-registration subprocess.

11.   The method of Claim 9, wherein the re-registration subprocess further comprises steps of:

noting the send time of an RRQ for re-registration;

noting the receipt time of a corresponding RRP; and

determining the current estimated round trip delay according to the formula:

$$RTT(current) = RRP(x\_t) - RRQ(x\_t),$$

wherein $RTT(current)$ represents the current estimated round trip delay, $RRP(x\_t)$ represents the receipt time of the RRP associated with the current re-registration attempt, and $RRQ(x\_t)$ represents the send time of the RRQ associated with the current re-registration.

12.   The method of Claim 8, wherein the current round trip estimation process further comprises an echo subprocess.

13.   The method of Claim 12, wherein the echo process further comprises the steps of:

noting a send time of an ICMP echo request from the mobile device to the

Express Mail No. EL977101169US   PATENT
Atty. Docket No. 030216

22

agent device;

noting the receipt time of a corresponding ICMP echo from the agent device to the mobile device; and

determining the current estimated network delay according to the formula:

$$RTT(current) = (ECHO(receive) - ECHO(send)),$$

wherein *RTT(0)* represents the current estimated round trip delay, *ECHO(receive)* represents the receipt time of the corresponding ICMP echo received from the home agent, and *ECHO(send)* represents the send time of the ICMP echo request.

14.   The method of Claim 8, wherein the current round trip estimation process further comprises a packet correlation process.

15.   The method of Claim 14, wherein the packet correlation process further comprises the steps of:

noting the send time of a TCP packet sent from the mobile device to the home agent;

noting the receipt time of a corresponding acknowledgment sent from the home agent to the mobile device; and

determining the current estimated network delay according to the formula:

$$RTT(current) = (ACK(receipt) - PACKET(send)),$$

wherein *RTT(current)* represents the current estimated round trip delay, *ACK(receipt)* represents the receipt time of the acknowledgment, and *PACKET(send)* represents the send time of the TCP packet.

16.   A method for determination of unloaded link latency in a Mobile IP network, the method comprising steps of:

(a)   noting a send time of an initial registration request from the mobile device to the home agent;

(b)   noting a receipt time of a registration reply corresponding to the

Express Mail No. EL977101169US   PATENT
Atty. Docket No. 030216

23

initial registration request from the home agent to the mobile device;

   (c) determining an unloaded network delay according to the formula:

$$RTT(0) = (RRP(initial) - RRQ(initial)),$$

wherein *RTT(0)* represents the initial registration round trip delay, *RRP(initial)* represents the receipt time of the initial registration reply, and *RRQ(initial)* represents the send time of the initial registration request;

   (d) setting a current estimated delay equal to the unloaded network delay;

   (e) noting a send time of a request for re-registration;

   (f) setting a retry timer equal to the sum of a predetermined backoff period and the current estimated network delay;

   (g) if the retry timer expires before receipt of a registration reply message, updating the predetermined backoff period and repeating steps (e), (f) and (g); and

   (h) if the retry timer does not expire before receipt of the registration reply message, noting the receipt time of the re-registration reply message and setting the current estimated delay equal to the difference between the receipt time and the send time.

   17. A method for determination of link latency in a communication network having a link, the method comprising:

   (a) a step for calculating an unloaded network delay for round trip traversal of the link according to an initial registration process;

   (b) a step for establishing a current estimated delay according to the unloaded network delay;

   (c) a step for adding a predetermined backoff period to the current estimated delay;

   (d) a step for setting a retry timer upon commencement of a Mobile IP registration attempt, the retry timer set according to the sum derived in step (c);

Express Mail No. EL977101169US   PATENT
Atty. Docket No. 030216

24

(e)   optionally, a step for initiating the current round trip delay estimation process;

(f)   if step (e) was initiated, a step for updating the current estimated round trip delay if the end event of the current round trip delay estimation process occurs;

(g)   a step for recalculating the backoff period and repeating steps (e) and (f) if the retry timer expires before the end time of the current round trip estimation process ; and

(h)   a step for determining the current estimated delay according to the difference between the end time of the current round trip estimation process and the start time of the current round trip estimation process, if the retry timer does not expire before the end time of the current round trip estimation process.

18.   The method of Claim 17, further comprising an initial step of providing a wireless communication sub-network utilizing Mobile IP, wherein the wireless communication sub-network incorporates the link.

19.   The method of Claim 18, wherein the link further comprises a link between a mobile device and a home agent.

20.   The method of Claim 17, wherein:

the current round trip estimation process further comprises a re-registration attempt;

the start time further comprises a send time of a re-registration request; and

the end time further comprises the receipt time of a re-registration reply.

21.   The method of Claim 17, wherein the step for establishing a current estimated delay further comprises:

a step for establishing a current estimated delay according to an echo subprocess.

Express Mail No. EL977101169US   PATENT
Atty. Docket No. 030216

25

22.   The method of Claim 17, wherein the step for establishing a current estimated delay according to the unloaded network delay further comprises:

a step for establishing a current estimated delay according to a packet subprocess.

23.   A communication network system having a link, the system comprising:

a first device;

a second device;

a communication path linking the first device and the second device; and

at least one module that determines the link latency associated with traversal of the communication path between the first device and the second device.

24.   The system of Claim 23, wherein:

the first device further comprises a mobile device; and

the second device further comprises a home agent.

25.   The system of Claim 24, further comprising an intermediary device for relaying communication between the mobile device and the home agent via the communication path.

26.   The system of Claim 23, wherein the at least one module further comprises:

an unloaded delay module for determining the unloaded network delay for round trip traversal of the link according to an initial registration process;

a current estimated delay module for setting a current estimated delay equal to a provided network delay value;

a request send time module for noting the start time of a current round trip estimation process ;

Express Mail No. EL977101169US   PATENT
Atty. Docket No. 030216

26

a retry timer module for setting a retry timer equal to the sum of predetermined backoff period and the current estimated network delay upon commencement of a current round trip estimation process having a start time and an end time;

a timer expiration module for updating the predetermined backoff period and notifying the retry timer module if the retry timer expires before the end time of the current round trip estimation process ;

a registration reply receipt time module for noting the end time of a current round trip estimation process; and

a reset module for setting the current estimated delay equal to the difference between the end time of the current round trip estimation process and the start time of the current round trip estimation process.

27.   The system of Claim 26, wherein:

the current round trip estimation process further comprises a re-registration subprocess;

the start time further comprises a send time of a re-registration request; and

the end time further comprises a receipt time of a re-registration reply.

28.   The system of Claim 27, wherein the current round trip estimation process further comprises a process selected from a group consisting of a re-registration subprocess; an echo subprocess; and a packet subprocess.

29.   The system of Claim 28, wherein the re-registration process further comprises:

noting a send time of a re-registration request from the mobile device to the home agent;

noting a receipt time of a re-registration reply corresponding to the initial registration request from the home agent to the mobile device; and

Express Mail No. EL977101169US   PATENT
Atty. Docket No. 030216

27

determining the unloaded network delay according to the formula:

$$RTT(current) = (RRP(x\_t) - RRQ(x\_t)),$$

wherein *RTT(current)* represents the current estimated round trip delay, *RRP(x_t)* represents the receipt time of the RRP associated with the current re-registration attempt, and *RRQ(x_t)* represents the send time of the RRQ associated with the current re-registration.

30.   The system of Claim 28, wherein the echo subprocess further comprises:

noting a send time of an ICMP echo request from the mobile device to the agent device;

noting the receipt time of a corresponding ICMP echo from the agent device to the mobile device; and

determining the loaded network delay according to the formula:

$$RTT(t) = (ECHO(receive) - ECHO(send)),$$

wherein *RTT(current)* represents the current estimated round trip delay, *ECHO(receive)* represents the receipt time of the corresponding ICMP echo received from the home agent, and *ECHO(send)* represents the send time of the ICMP echo request.

31.   The system of Claim 28, wherein the current round trip estimation process further comprises:

noting the send time of a TCP packet sent from the mobile device to the home agent;

noting the receipt time of a corresponding acknowledgment sent from the home agent to the mobile device; and

determining the loaded network delay according to the formula:

$$RTT(t) = (ACK(receipt) - PACKET(send)),$$

wherein *RTT(0)* represents the current estimated round trip delay, *ACK(receipt)* represents the receipt time of the acknowledgment, and *PACKET(send)* represents the send time of the TCP packet.

Express Mail No. EL977101169US   PATENT
Atty. Docket No. 030216

28

32.   A communication network, comprising:

means for providing a first device;

means for providing a second device;

means for communication between the first device and the second device;

means for determining an unloaded network delay for round trip traversal of the link during initial Mobile IP registration;

means for setting a current estimated delay equal to the unloaded network delay;

means for setting a retry timer equal to the sum of a predetermined backoff period and the current estimated network delay;

means for updating the predetermined backoff period and resetting the retry timer equal to the sum of the predetermined backoff period and the current estimated network delay when the retry timer expires before an end time of a current round trip estimation process; and

means for resetting the current estimated delay equal to the difference between the end time of the current round trip estimation process and a start time of the current round trip estimation process when the retry timer does not expire prior to the end time of a current round trip estimation process .

33.   The network of Claim 32, further comprising a wireless communication sub-network employing Mobile IP.

34.   The network of Claim 33, wherein:

the means for providing the first device further comprises a mobile device; and

the means for providing the second device further comprises a home agent.

Express Mail No. EL977101169US   PATENT
Atty. Docket No. 030216

29

35.   The network of Claim 34, further comprising an intermediary device for relaying communications between the mobile device and the home agent via the means for communication.

36.   The network of Claim 34, wherein the Mobile IP registration further comprises an initial registration process.

37.   The network of Claim 36, wherein the initial registration process further comprises:

means for noting a send time of an initial registration request from the mobile device to the home agent;

means for noting a receipt time of a registration reply corresponding to the initial registration request from the home agent to the mobile device; and

means for determining the unloaded network delay according to the formula:

$$RTT(0) = (RRP(initial) - RRQ(initial)),$$

wherein $RTT(0)$ represents the initial registration round trip delay, $RRP(initial)$ represents the receipt time of the initial registration reply, and $RRQ(initial)$ represents the send time of the initial registration request.

38.   The network of Claim 34, further comprising an additional network and an associated echo subprocess for current estimated round trip delay determination.

39.   The network of Claim 38, wherein the echo process further comprises:

means for noting a send time of an ICMP echo request from the mobile device to the agent device;

means for noting the receipt time of a corresponding ICMP echo from the home agent to the mobile device; and

means for determining the unloaded network delay according to the formula:

$$RTT(t) = (ECHO(receive) - ECHO(send)),$$

wherein *RTT(t)* represents the current echo round trip delay value at time t, *ECHO(receive)* represents the receipt time of the corresponding ICMP echo received from the home agent, and *ECHO(send)* represents the send time of the ICMP echo request.

40.   The network of Claim 34, further comprising a packet correlation subprocess for current estimated round trip delay determination.

41.   The network of Claim 40, wherein the packet correlation process further comprises:

means for noting the send time of a TCP packet sent from the mobile device to the home agent;

means for noting the receipt time of a corresponding acknowledgment sent from the home agent to the mobile device; and

means for determining the unloaded network delay according to the formula:

$$RTT(t) = (ACK(receipt) - PACKET(send)),$$

wherein *RTT(t)* represents the current packet round trip delay value at time t, *ACK(receipt)* represents the receipt time of the acknowledgment, and *PACKET(send)* represents the send time of the TCP packet.

42.   The network of Claim 34, wherein:

the current round trip estimation process further comprises a re-registration attempt;

the start time further comprises a send time of a re-registration request; and

the end time further comprises a receipt time of a re-registration reply.

43.   A wireless communication sub-network, comprising:

a mobile station;

a home agent;

a communication path linking the mobile station and the home agent; and

Express Mail No. EL977101169US   PATENT
Atty. Docket No. 030216

31

at least one module for determining latency between the mobile station and the home agent.

44.   The sub-network of Claim 43, further comprising an intermediary device.

45.   The sub-network of Claim 44, wherein the intermediary device further comprises at least one device selected from the group consisting of a foreign agent; a mobility anchor point; and a packet data serving node.

46.   The sub-network of Claim 43, wherein the mobile station further comprises at least one component selected from the group consisting of a terminal equipment, a mobile device, a transmitter, and a receiver.

47.   The sub-network of Claim 43, wherein the at least one module further comprises at least one module selected from the group consisting of an unloaded network delay module; a current estimated delay module; a request send time module; a retry timer module; a timer expiration module; a registration reply module; and a reset module.

48.   A Mobile IP communications network, comprising:

a mobile device;

a home agent;

means for communication between the mobile device and the home agent;

means for noting a send time of an initial registration request from the mobile device to the home agent via the means for communication;

means for noting a receipt time of a registration reply corresponding to the initial registration request from the home agent to the mobile device via the means for communication;

means for determining the unloaded network delay according to the formula:

$$RTT(0) = (RRP(initial) - RRQ(initial)),$$

Express Mail No. EL977101169US   PATENT
Atty. Docket No. 030216

32

wherein *RTT(0)* represents the initial registration round trip delay, *RRP(initial)* represents the receipt time of the initial registration reply, and *RRQ(initial)* represents the send time of the initial registration request;

means for setting a current estimated delay equal to the unloaded network delay;

means for noting a send time of a request for re-registration from the mobile device to the home agent via the means for communication;

means for setting a retry timer equal to the sum of a predetermined backoff period and the current estimated network delay;

means for updating the predetermined backoff period and means for resetting the retry timer if the retry timer expires before receipt of a registration reply message;

means for noting the receipt time of the registration reply message from the home agent to the mobile device via the communications path; and

means for setting the current estimated delay equal to the difference between the receipt time (end event) and the send time (start event).

49.   A Mobile IP communications network, comprising:

a mobile device;

a home agent;

a communication path linking the mobile device and the home agent;

an unloaded network delay module for determining an unloaded network delay for traversal of the communication path between the mobile device and the home agent according to an initial registration process;

a current estimated delay module for setting a current estimated delay equal to the unloaded or loaded network delay;

a request send time module for noting a send time of a request for re-registration between the mobile device and the home agent via the communication path;

a retry timer module for setting a retry timer equal to the sum of a

predetermined backoff period and the current estimated network delay;

a timer expiration module for updating the predetermined backoff period and notifying the retry timer module if the retry timer expires before receipt of a re-registration reply message from the home agent to the mobile device via the communication path;

a registration reply receipt time module for noting the receipt time of the re-registration reply message by the mobile device; and

a reset module for setting the current estimated delay equal to the difference between the receipt time and the send time.